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Stock Status of Witch Flounder in NAFO Subdivision 3Ps

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Abstract

Landings from this stock over the last 20 years have fluctuated generally between 300t and 1000 t annually but have not exceeded 500t since 1993. Survey stock size indices since 1976 have been highly variable although recent estimates appear to be at the low end of the range. Survey results suggest that the recent biomass levels may be about two thirds of that of the late 1980's and early 1990's when the stock appeared relatively stable at a catch level of 1000t annually. The age and size structure observed in this stock since the early 1980s also appear to have remained stable with little change in growth pattern. Geographic distribution has not changed appreciably since 1983 except during the early to mid 1990's when fish disappeared from the 51-100 fath. depth zone coincident with extremely cold sea bottom water temperatures. Relative mortality rates indicate little change during the past 20 years although there may have been some increase in the mid-1990s. Data from surveys and recent observations from the commercial fishing industry suggest that witch flounder in Subdiv. 3Ps are found in deeper water than in past years.

Résumé

Au cours des vingt dernières années, les débarquements provenant de ce stock ont généralement fluctué entre 300 t et 1 000 t par année, mais ils n'ont pas excédé 500 t depuis 1993. Depuis 1976, les indices sur la taille du stock obtenus par relevés ont été très variables; les dernières estimations semblent être parmi les plus faibles. Les résultats des relevés montrent que le niveau récent de la biomasse se situe à environ les deux tiers de celui de la fin des années 1980 et du début des années 1990, période où la taille du stock était relativement stable, avec un niveau de prises de 1 000 t par année. La structure selon l'âge et la taille de ce stock observée depuis le début des années 1980 est aussi demeurée relativement stable, avec peu de changements dans le mode de croissance. La répartition géographique n'a pas beaucoup changé depuis 1983, sauf entre le début et le milieu des années 1990, alors que le poisson a disparu de la zone située entre 51 et 100 brasses de profondeur, ce qui coïncide avec une température au fond de l'eau étant extrêmement froide. Les taux de mortalité relatifs n'ont pas vraiment changé durant les 20 dernières années, même s'il y a eu une légère augmentation au milieu des années 1990. Les données provenant des relevés et des observations faites récemment dans le cadre de la pêche commerciale montrent que la plie grise de la sous-division 3Ps se retrouve à de plus grandes profondeurs que par le passé.

Description of the fishery

With the exception of 1977 when landings were reported to be about 3800 tons, landings of witch flounder in NAFO Subdiv. 3Ps fluctuated mainly between about 300 and 1000 t annually since the early 1970's (Table 1;Fig. 1). From 1986-93, landings were relatively stable averaging around 1000 tons annually, however, since then have not exceeded 500 tons and were as low as 250 tons in 1996 (Table 1;Fig. 1). During the 1980's the catch was primarily a by-catch of other groundfish fisheries, however, in recent years with the severe declines in major groundfish resources (cod and other flatfish species in particular) certain sectors of the fishing industry had come to depend more on this stock.

Landings from this stock have been taken mainly by Canadian trawlers fishing offshore on St. Pierre Bank. However, a significant portion of the landings is taken by small Scottish/Danish seiners and gill-netters fishing primarily in Fortune Bay, Statistical Area 3Psb, off the south coast of Newfoundland (Tables 2 and 3;Fig. 2 and 3). Prior to the boundary settlement between Canada and France, fishermen from St. Pierre and Miquelon also caught small amounts of witch flounder on St. Pierre Bank although this no longer appears to be the case (Table 1).

The fishing pattern for offshore Canadian participants since about 1993 has remained much the same with fishing being conducted mostly at the south-eastern tip of St. Pierre Bank in depths ranging from 200 to 900 m and sometimes deeper. As a result of the closure of the American plaice and cod fisheries in Subdiv. 3Ps from 1994, combined with a 5% by-catch constraint, the fishery for witch flounder has been seriously hampered and have at least partly resulted in the low catch levels since then. Although most of the seine and gillnet landings have been in area 3Psb there have been some increase in the landings in 3Psa in recent years (Table3; Fig. 3).

The first total allowable catch (TAC) was established for this stock in 1974 at 3000 tons which remained in effect until 1988 when it was reduced to 1000 tons (Fig. 1). It was further reduced to 500 tons in 1996 and 1997 but was increased again to 650 tons for 1998 and 1999.

Research Vessel Surveys

i) *Vessel / Gear Conversions*

During 1995 the Canadian Department of Fisheries and Oceans, Science Branch, Newfoundland Region replaced its *Engel* bottom otter trawl with bobbin footgear used in groundfish surveys with a *Campelen 1800* shrimp trawl using rockhopper footgear. In order to ensure an orderly transition and maintain continuity with the older data time series, comparative-fishing trials were conducted in 1996 to develop conversion factors between the two fishing gears. The trials were conducted between the research vessel *Wilfred Templeman* (the regular survey vessel) using the new survey gear and its sister ship *Alfred Needler* using the old survey gear. It was assumed that there was no difference between vessels and that the only observed differences in catch were a result of the use of the different fishing gears. Six target species were investigated (one being witch flounder) because of their commercial significance and management requirements. A thorough description of the experimental design and mathematical determinations can be found in Warren et al. (1997) and thus will not be described in detail here.

Length frequencies, standardised for towing distance, for witch flounder in NAFO Subdiv. 3Ps were converted from Engel 145 trawl catches to Campelen 1800 trawl catch equivalents for the years beginning in 1983 (the year the Engel 145 trawl was introduced as the standard survey trawl in this area). The data converted were winter-spring surveys in Subdiv. 3Ps during 1983-95. All subsequent surveys were actually carried out using the Campelen 1800 trawl. Conversion factors as presented in Warren et al. (1997) for witch flounder were applied using weighted least squares as follows:

For the converted length y_i

$$y_i = \beta^* n_i$$

where

n_i = number at length in the set

$$\beta = e^{a} X_i^{b} e^{cx_i}$$

x_i = midpoint of length class
a = 23.209213, b = -7.475675 and c = 0.11559
β was set at 8.41 for $x_i<24$ and β was set at 0.75 for $x_i>49$

Weights were applied as the number of fishing sets used to estimate the ratio for a given length class.

After the length frequencies were converted to Campelen trawl catch equivalents they were summed to provide total numbers of witch flounder caught per standard Campelen set (0.8 nautical mile tow distance in 15 minutes with a wing spread of 16.84 m). Using various combinations of length-weight relationships available from surveys during the 1990's, the converted length frequencies were adjusted also to provide the total weights caught per standard Campelen set. The impact of the change in survey gear on length frequency distributions is illustrated in Fig. 4 and age frequency distributions for Engel 145 in Fig. 5 and Campelen 1800 in Fig. 6. As anticipated from the equations above, the numbers at length and age are considerably higher at smaller sizes and younger ages whereas the differences are small when fish become progressively larger and older.

ii) *Survey Abundance and Biomass Indices*

The estimated abundance and biomass (tons) by stratum and year for Campelen 1800 data from 1983-99 and Engel 145 data for 1983-95 are presented for detailed information purposes in Tables 4-7, respectively, with a graphic comparison of the biomass trends shown in Fig. 7. A map illustrating the location of the respective strata is shown in Fig. 8. Abundance and biomass indices have been highly variable over the past 15 years showing little in the way of distinct trends (Tables 4-7; Fig. 7). However, a lowess smoother drawn through the data points suggest that a general decline in biomass occurred in the late 1980's for the Engel data series and in the early 1990's for the Campelen data series (Fig. 9). Both suggest that the recent biomass levels be about two thirds of that of the 1980's when the stock appeared relatively stable.

A cursory examination of survey indices by depth zone indicated that up until about 1988 there was considerable biomass in 93-183 m (51-100 fath) whereas during 1990-97 there was very little (Table 4). More recently, however, witch flounder are again appearing in higher abundance in this depth zone especially during the 1999 survey (Tables 4-7). It is possible that this is a distribution shift to and from the area related to bottom temperature. During the period of absence the bottom temperatures were extremely cold being negative in all years from 1990-95 within this depth zone (Table 8). Prior to this period and since then, bottom temperatures within this depth zone were considerably higher with both the 1998 and 1999 temperature well above the average of the entire period (Table 8).

iii) *Geographic distribution*

Distribution plots of witch flounder in Subdivision 3Ps are presented as Canadian survey catches (kg/set) based on the Campelen equivalent catches for the survey years 1983-99 (Fig. 10). Witch flounder are generally distributed in the deeper water along the southwestern slope of St. Pierre Bank and throughout the Laurention and Hermitage Channels. Few, if any, are caught on the shallow parts of St. Pierre Bank or Green Bank or Burgeo Bank. Although recent surveys have been extended to some degree into Fortune Bay and Placentia Bay none have been encountered. On the other hand, the distribution does extend from Hermitage Channel to Hermitage Bay (Fig. 10). Overall, the distribution of witch flounder does not appear to have changed greatly with one exception. As stated above, during years of cold bottom temperatures few witch flounder are caught in the 93-183m-depth zone whereas in years of warmer temperatures they are more widespread in this area. Geographically, this seems to be representative of the Halibut Channel region. Nevertheless, the difference in distribution pattern appears to have little impact on the overall abundance and biomass index.

iv) *Catch at age and length*

Survey catch-at-age data are presented for 1983-94 (Fig. 5 and 6). Due to the scaling down of the witch flounder research program no ageing data have been available since then. During most years the age composition is usually represented by an age range from 4-12 years old but generally peaking at 7-8 with these two age groups comprising half of the catch (Fig. 6). The age structure has been relatively stable during the period shown, however, historically witch flounder in Subdivision 3Ps comprised fish up to 22 years old with most of the catch over age 10 (Bowering 1989).

Length compositions from the Campelen converted data from 1983-95 show that the survey catches generally represent fish in the length range of about 20-50 cm with a peak in the 25-35 cm range (Fig. 4). Few fish are caught over 50 cm (Fig. 4). A comparison with length composition data from the 1996-99 surveys actually using the Campelen reveal similar results which may suggest little overall variation in size composition at least during the last 17 years (Fig. 11).

The trend in mean size at age from 1983-94 where age data were available suggests little change in growth for at least the last 6-7 years of the period examined (Table 9; Fig. 12). If this apparent stability is assumed to have continued to 1999 then based on the length compositions from 1983-1999 is could be assumed that there has been little appreciable change in the age composition at least since 1983.

v) *Total Mortality Trends*

Estimates of total mortality (Z) were calculated from survey data for ages 4-12 using Engel unconverted data in order to extend the number of data points (Fig. 13). Lowess smoothers also were added to the individual plots to help discern any trends in the mortality calculations. Although the data were highly variable, ages 7-9 showed a generally increasing trend from the late 1970's to the early 1990's with the ages 10-12 data rather flat (Fig. 13). A further examination of relative trends in total mortality was carried out by conducting a multiple regression analysis using fully recruited cohorts (ages 8-13) from 1976-94 (Engel data) and utilising the information in the age*cohort interaction term (Fig. 14). The results indicate no trend in mortality over the cohorts of 1965-79 with an increasing trend to 1984. Although there was a drop in relative mortality for the 1985-86 year-classes they are estimated by only 2 and 1 data points, respectively.

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Table 1. Landings of witch flounder in Subdivision 3Ps by country during 1974-98.

	COUNTRY							
	CAN(MQ)	CAN(N)	FRA(SP)	POR	USSR	FRA(M)	CAN(M)	TOTAL
Year								
1974	94	1605	47	40	-	-	-	1786
1975	-	1179	-	-	4	-	-	1183
1976	40	801	-	-	-	-	-	841
1977	-	3841	-	-	-	-	-	3841
1978	23	969	-	-	-	-	-	992
1979	-	561	-	-	-	-	-	561
1980	-	790	-	-	-	-	-	790
1981	-	412	53	-	-	-	4	469
1982	-	334	0	-	-	-	-	334
1983	-	154	125	-	-	-	-	279
1984	-	325	34	-	-	2	-	361
1985	-	376	118	-	-	2	-	496
1986	-	613	606	-	-		110	1329
1987	-	1131	71	-	-	53	18	1273
1988	-	475	53	-	-	6	102	636
1989	-	831	67	-	-	-	29	927
1990	-	940	-	-	-	-	31	971
1991	-	1056	-	-	-	-	59	1115
1992	-	1012	50	-	-	-	68	1130
1993	-	956	-	-	-	-	17	973
1994	-	429	-	-	-	-	2	431
1995	-	273	-	-	-	-	1	274
1996	-	250	-	-	-	-	6	256
1997	-	282	7	-	-	-	30	319
1998	-	-	-	-	-	-	-	473
1999	-	-	-	-	-	-	-	472

** 1998-99 from Canadian quota reports only. 1999 to the end of September.

Table 2. Landings of witch flounder in Subdivision 3Ps by gear type during 1974-99 for Canada (N) only.

	GEAR				
YEAR	OTB	SEINES	OTHER	TOTAL	TAC
1974	1409	177	19	1605	3000
1975	684	491	4	1179	3000
1976	590	153	58	801	3000
1977	3387	454	-	3841	3000
1978	627	342	-	969	3000
1979	484	75	2	561	3000
1980	569	219	2	790	3000
1981	168	233	11	412	3000
1982	284	50	-	334	3000
1983	147	1	6	154	3000
1984	322	-	3	325	3000
1985	198	175	3	376	3000
1986	285	297	31	613	3000
1987	879	217	35	1131	3000
1988	260	153	62	475	1000
1989	557	196	78	831	1000
1990	635	244	61	940	1000
1991	789	195	72	1056	1000
1992	761	214	37	1012	1000
1993	712	183	61	956	1000
1994	131	288	10	429	1000
1995	3	270	-	273	1000
1996	78	171	1	250	500
1997	156	126	-	282	500
1998	288	-	-	473	650
1999	304	-	-	472	650

** 1998-99 from Canadian quota reports only.
1999 to the end of September.

Table 3. Landings of witch flounder in Subdivision 3Ps by statistical area from 1985-98.

	Statistical Area							
Year	3Psa	3Psb	3Psc	3Psd	3Pse	3Psf	3Psg	3Psh
1985	15	113	-	36	12	26	94	120
1986	16	227	2	68	5	14	136	163
1987	49	151	1	52	7	44	236	539
1988	4	70	2	37	1	8	58	238
1989	11	167	2	8	-	12	73	476
1990	5	179	2	25	11	3	286	322
1991	4	71	3	10	-	6	115	590
1992	16	62	-	7	-	5	281	464
1993	4	259	-	7	-	-	88	593
1994	7	317	3	1	-	-	1	109
1995	16	213	40	2	-	-	1	2
1996	89	80	-	3	-	-	-	82
*1997	47	76	-	-	-	-	16	148
1998	121	64	6	5	-	-	1	258

*There were 287 tons not reported by gear and area

Table 4. Witch abundance estimates (000s of fish) from research vessel surveys in NAFO Subdivision 3Ps from 1983-99. Estimates are presented in Campelen trawl catch units.

Depth range (fathoms)	Strata	Vessel / Trips / Sets / Mean Da / sq. mi.	AN 9 164 30-Apr 1983	AN 26 93 13-Apr 1984	WT 26 109 13-Mar 1985	WT 45 136 15-Mar 1986	WT 55-56 130 7-Mar 1987	WT 68 146 5-Feb 1988	WT 81 146 9-Feb 1989	WT 91 108 9-Feb 1990	WT 103 158 10-Feb 1991	WT 118 137 14-Feb 1992	WT 133 136 13-Feb 1993	WT 135 130 11-Apr 1993	WT 150-151 166 15-Apr 1994	WT 166-167 161 16-Apr 1995	WT 186-187 148 22-Apr 1996	WT 202-203 158 12-Apr 1997	WT 219-220 176 21-Apr 1998	WT 236-237 175 24-Apr 1999
<30	314	974	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0
	320	1320	532	0	0	0	0	0	0	0	0	0	0	318	0	30	0	0	0	0
31-50	293 [4]	159	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0
	308	112	0	0	0	0	0	31	0	0	0	0	0	0	0	0	0	0	0	8
	312	272	0	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	315	827	264	796	0	265	0	341	179	0	0	0	0	0	0	0	0	0	16	72
	321	1189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	0	0	0
	325	944	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
	326	166	0	0	.	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0
	783 [1]	229	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.	0	0	0
51-100	294 [4]	135	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0
	297 [4]	152	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	53	0	660
	307	395	408	109	290	18	0	0	0	0	0	0	0	54	353	0	41	0	0	223
	311	317	0	414	55	5945	15	240	58	0	44	0	15	0	33	87	0	0	15	1509
	317	193	9779	16467	252	544	9	690	0	0	0	119	0	53	0	0	0	0	478	2217
	319	984	445	336	68	761	587	457	4010	.	60	0	0	0	0	406	1339	15	1946	846
	322	1567	39	620	0	162	0	36	0	0	0	0	0	0	0	33	150	118	29	32
	323	696	1548	48	319	19	383	36	41	0	0	0	0	0	0	0	22	24	207	46
	324	494	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	781 [1]	446	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	0	0
	782 [1]	183	.	.	.	.	.	.	.	.	.	.	.	.	0	0	.	0	0	13
101-150	295 [4]	209	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	661	1073	14
	298 [4]	171	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	354	502	955
	300 [4]	217	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	371	2421	1030
	306	363	620	58	317	1114	144	43	134	0	922	115	58	29	86	100	1493	766	188	610
	309	296	556	183	828	305	122	231	163	244	529	305	27	160	601	556	790	457	706	41
	310	170	70	105	304	257	316	70	374	117	35	94	58	35	296	164	129	66	373	316
	313	166	1687	193	340	375	125	863	863	4142	340	1997	329	1975	5062	3007	896	295	1291	363
	316	189	6357	3874	4368	3952	4787	14975	5607	14403	143	14975	.	9940	1430	1729	6071	11128	4901	2590
	318	129	1128	178	.	3443	178	1870	76	.	4662	102	288	4941	0	6548	719	311	825	201
	779 [1]	422	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	19	82
	780 [1]	403	.	.	.	.	.	.	.	.	.	.	.	.	0	0	.	0	0	156
151-200	296 [4]	71	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	352	191	102
	299 [4]	212	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1492	2341	1721
	705	195	957	429	912	1113	590	2106	1194	456	2133	1523	550	724	581	711	891	1019	1085	440
	706	476	5998	3372	2488	4273	5147	3536	2063	5959	8300	6827	2728	5029	4240	7350	3318	2447	4551	1855
	707	74	444	198	.	403	512	192	294	.	6141	2309	678	409	0	2698	75	59	148	23
	715	128	751	163	.	209	309	327	890	36	0	163	45	413	295	660	471	72	76	44
	716	539	1112	939	1691	4041	2373	2491	2892	3589	1987	2894	2002	1261	1394	756	5058	1598	2816	968
201-300	708	126	531	370	.	628	370	121	853	.	3275	467	660	225	1421	225	503	14294	193	29
	711	593	10724	7853	11088	15114	6459	5760	9575	8593	9452	17582	3913	5526	3083	7260	5364	2471	3446	3945
	712	731	6136	.	14857	10529	7161	6922	7077	7856	13652	18498	4264	3251	3557	14911	8195	4384	5499	3067
	713	851	3715	.	5472	6848	8200	8252	5668	7150	13068	12742	8670	3485	4313	6087	7036	6621	7682	4433
	714	1074	2252	.	.	9140	5055	10356	8532	8712	12254	8924	4588	4932	2301	7461	7040	7394	6395	3892
301-400	709 [2]	147	20	7	.	.	.	.	647	.	1631	.	508	92	283	5955	718	.	1345	1336
401-500	710 [1]	156	87	42	82	183	.	10	.	.	74	.	87	30	436	.	.	.	.	441
501-600	776 [1]	159	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
601-700	777 [1]	183	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
701-800	778 [1]	166	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total [3]		56,181	36,877	43,730	69,622	42,819	59,956	51,189	61,057	78,702	89,336	29,668	42,903	29,943	66,736	50,401	56,832	50,780	34,295

[1] These strata were added to the stratification scheme in 1994.

[2] Strata 709 was redrawn in 1994 and includes the area covered by strata 710 in previous surveys. All sets done in 710 prior to 1994 have been recoded to 709.

[3] totals are for all strata fished .

[4] These strata were added to the stratification scheme in 1997.

Table 5. Witch biomass estimates (tons) from research vessel surveys in NAFO Subdivision 3Ps from 1983-99. Estimates are presented in Campelen trawl catch units.

Depth range (fathoms)	Strata		Vessel	AN	AN	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT
			Trips	8	26	26	45	65-56	68	81	91	103	118	133	135	150-151	166-167	186-187	202-203	219-220	236-237
			Sets	164	93	109	136	130	146	146	108	158	137	136	130	166	161	148	158	176	175
			Mean Da	30-Apr	13-Apr	13-Mar	15-Mar	7-Mar	5-Feb	9-Feb	9-Feb	10-Feb	14-Feb	13-Feb	11-Apr	15-Apr	18-Apr	22-Apr	12-Apr	21-Apr	24-Apr
			sq. mi.	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1993	1994	1995	1996	1997	1998	1999
<30	314		974	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0
	320		1320	200	0	0	0	0	0	0	0	0	0	0	64	0	19	0	0	0	0
31-50	293	4	159	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0
	308		112	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
	312		272	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	315		827	134	273	0	68	0	76	44	0	0	0	0	0	0	0	0	0	5	35
	321		1189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	325		944	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	326		166	0	0	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	783	1	229	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.	0	0	0
51-100	294	4	135	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0
	297	4	152	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	0	122
	307		395	51	49	39	13	0	0	0	0	0	0	0	10	64	0	1	0	0	81
	311		317	0	139	27	1564	6	79	7	0	7	0	5	0	9	15	0	0	2	416
	317		193	3253	4662	75	144	4	154	0	0	0	42	0	22	0	0	0	0	76	430
	319		964	171	230	93	319	242	170	1716	.	21	0	0	0	0	93	618	8	629	265
	322		1567	31	121	0	24	0	10	0	0	0	0	0	0	0	8	1	1	0	0
	323		696	791	30	285	14	166	30	35	0	0	0	0	0	0	0	10	0	1	24
	324		494	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	781	1	446	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	0	0
	782	1	183	.	.	.	.	.	.	.	.	.	.	.	.	0	0	.	0	0	0
101-150	295	4	209	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	109	203	0
	298	4	171	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	90	188	305
	300	4	217	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	44	268	79
	306		393	208	16	101	177	61	23	74	0	57	14	16	7	30	24	72	42	35	51
	309		296	126	79	238	90	12	29	36	46	57	20	15	50	104	87	31	53	52	22
	310		170	34	65	128	138	51	33	117	77	9	7	29	5	63	22	11	11	40	90
	313		165	335	62	103	100	32	198	249	747	58	285	59	471	1244	623	158	47	248	76
	316		189	1598	1139	1275	1198	1260	3595	1343	2830	28	3124	.	2175	333	209	1512	1802	857	619
	318		129	286	35	.	1196	57	551	30	.	1538	17	81	1492	0	1540	149	119	212	48
	779	1	422	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	0	1
	780	1	403	.	.	.	.	.	.	.	.	.	.	.	.	0	0	.	0	0	1
151-200	296	4	71	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	161	23	35
	299	4	212	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	371	674	430
	705		195	208	124	243	267	211	596	325	137	467	331	89	175	128	161	142	158	215	71
	706		476	1218	817	621	1067	1461	935	481	1205	2032	1482	764	1387	675	1442	571	491	873	316
	707		74	117	44	.	152	180	62	116	.	2007	675	234	200	0	666	12	15	36	8
	715		128	173	48	.	84	112	93	248	28	0	43	14	106	68	139	90	20	12	23
	716		539	401	355	597	1321	938	920	918	1042	519	706	528	366	304	208	1045	275	460	242
201-300	708		126	97	80	.	186	148	55	251	.	1741	167	239	62	342	64	92	4988	29	3
	711		593	1540	1218	1517	2385	1239	1058	1572	1470	1417	3378	846	1119	492	1078	667	328	464	471
	712		731	940	.	2006	1557	1047	1228	944	1265	1946	3003	891	515	662	2011	860	446	636	321
	713		851	566	.	786	1073	1769	1240	919	1066	2149	2113	1526	554	690	903	718	846	625	451
	714		1074	371	.	.	2153	937	2010	1344	1560	2309	1871	818	757	374	1136	747	1130	702	412
301-400	709	2	147	3	2	.	.	.	.	137	.	379	.	114	38	42	890	59	.	126	137
401-500	710	1	156	15	11	13	28	.	4	.	.	17	.	21	1	57	.	.	.	.	39
501-600	776	1	159	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
601-700	777	1	183	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
701-800	778	1	166	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total	3		12,865	9,640	8,147	15,315	9,929	13,155	10,907	11,492	16,757	17,280	8,285	9,557	5,878	11,337	7,564	11,556	7,891	5,628

[1] These strata were added to the stratification scheme in 1994.

[2] Strata 709 was redrawn in 1994 and includes the area covered by strata 710 in previous surveys. All sets done in 710 prior to 1994 have been recoded to 709.

[3] totals are for all strata fished .

[4] These strata were added to the stratification scheme in 1997.

Table 8. Witch abundance estimates (tons) from research vessel surveys in NAFO Subdivision 3Ps from 1983-95. Estimates are presented in Engel trawl catch units.

Depth range (fathoms)	Strata		Vessel Tripe Sets Mean Da sq. mi.	AN 9 164 30-Apr 1983	AN 26 93 13-Apr 1984	WT 26 109 13-Mar 1985	WT 45 136 15-Mar 1986	WT 55+56 130 7-Mar 1987	WT 68 146 5-Feb 1988	WT 81 146 9-Feb 1989	WT 91 108 9-Feb 1990	WT 103 158 10-Feb 1991	WT 118 137 14-Feb 1992	WT 133 136 13-Feb 1993	WT 135 130 11-Apr 1993	WT 150-151 166 15-Apr 1994	WT 166-167 161 16-Apr 1995
<30	314		974	0	0	0	0	0	0	0	0	0	0	0	10	0	0
	320		1320	212	0	0	0	0	0	0	0	0	0	0	74	0	17
31-50	293	[4]	159	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	308		112	0	0	0	0	0	8	0	0	0	0	0	0	0	0
	312		272	0	20	0	0	0	0	0	0	0	0	0	0	0	0
	315		827	124	298	0	83	0	83	53	0	0	0	0	0	0	0
	321		1189	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	325		944	0	14	0	0	0	0	0	0	0	0	0	0	0	0
	326		166	0	0	.	0	0	0	0	0	0	0	0	0	0	0
	783	[1]	229	.	.	.	.	.	.	.	.	.	.	.	0	.	.
51-100	294	[4]	135	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	297	[4]	152	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	307		385	52	59	40	10	0	0	0	0	0	0	0	10	74	0
	311		317	0	143	24	1713	8	89	8	0	8	0	8	0	12	16
	317		193	3477	5158	87	159	5	157	0	0	0	43	0	22	0	0
	319		984	169	185	37	305	238	175	1764	.	16	0	0	0	0	102
	322		1567	21	103	0	20	0	10	0	0	0	0	0	0	0	9
	323		696	740	26	209	10	148	21	22	0	0	0	0	0	0	0
	324		404	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	781	[1]	446	.	.	.	.	.	.	.	.	.	.	.	.	0	0
	782	[1]	183	.	.	.	.	.	.	.	.	.	.	.	.	0	0
101-150	295	[4]	209	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	298	[4]	171	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	300	[4]	217	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	306		363	197	16	110	189	55	24	63	0	79	16	16	8	31	27
	309		296	141	89	237	89	11	30	44	44	74	33	15	97	111	90
	310		170	38	57	119	128	57	30	128	51	13	6	32	6	72	26
	313		165	363	68	99	105	37	217	268	811	62	322	68	514	1319	681
	316		189	1749	1220	1381	1270	1357	3935	1480	3135	35	3448	.	2388	389	227
	318		129	305	37	.	1274	69	809	32	.	1653	16	97	1597	0	1695
	779	[1]	422	.	.	.	.	.	.	.	.	.	.	.	.	0	0
	780	[1]	403	.	.	.	.	.	.	.	.	.	.	.	.	0	0
151-200	296	[4]	71	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	299	[4]	212	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	705		195	224	132	242	285	220	637	359	146	512	359	95	188	142	176
	706		476	1308	893	679	1126	1601	1018	545	1322	2251	1651	834	1494	965	1572
	707		74	128	52	.	164	185	70	120	.	2108	733	248	199	0	725
	715		128	178	55	.	89	109	99	268	20	0	50	15	111	77	154
	716		539	405	391	631	1366	971	963	981	1109	542	715	546	354	340	227
201-300	708		126	105	88	.	206	158	53	272	.	1708	180	246	70	389	66
	711		593	1677	1342	1623	2581	1402	1154	1711	1635	1596	3788	987	1241	541	1184
	712		731	1043	.	2118	1656	1114	1346	1023	1388	2146	3338	991	574	751	2148
	713		851	601	.	820	1155	1872	1355	972	1100	2300	2303	1694	618	774	998
	714		1074	386	.	.	2081	994	2143	1480	1615	2430	1935	881	877	381	1209
301-400	709	[2]	147	4	4	.	.	.	.	151	.	396	.	129	40	42	966
401-500	710	[1]	156	18	12	15	30	.	4	.	.	20	.	23	2	59	.
501-600	776	[1]	159	.	.	.	.	.	.	.	.	.	.	.	.	.	.
601-700	777	[1]	183	.	.	.	.	.	.	.	.	.	.	.	.	.	.
701-800	778	[1]	166	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total	[3]		13,666	10,461	8,470	16,073	10,581	14,238	11,741	12,377	17,950	18,915	8,903	10,474	8,429	12,319

[1] These strata were added to the stratification scheme in 1994.

[2] Strata 709 was redrawn in 1994 and includes the area covered by strata 710 in previous surveys. All sets done in 710 prior to 1994 have been recoded to 709.

[3] totals are for all strata fished .

[4] These strata were added to the stratification scheme in 1997.

Table 7. Witch biomass estimates (tons) from research vessel surveys in NAFO Subdivision 3Ps from 1983-95. Estimates are presented in Engel trawl catch units.

Depth range (fathoms)	Strata		Vessel	AN	AN	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT
			Trips	9	26	26	45	55+56	68	81	91	103	118	133	135	150-151	166-167
			Sets	164	93	109	136	130	146	146	108	158	137	138	130	166	161
			Mean Da	30-Apr	13-Apr	13-Mar	15-Mar	7-Mar	5-Feb	9-Feb	9-Feb	10-Feb	14-Feb	13-Feb	11-Apr	15-Apr	16-Apr
			sq. mi.	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1993	1994	1995
<30	314		974	0	0	0	0	0	0	0	0	0	0	0	9	0	0
	320		1320	85	0	0	0	0	0	0	0	0	0	0	19	0	16
31-50	293	[4]	159	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	308		112	0	0	0	0	0	4	0	0	0	0	0	0	0	0
	312		272	0	10	0	0	0	0	0	0	0	0	0	0	0	0
	315		827	74	137	0	47	0	31	22	0	0	0	0	0	0	0
	321		1189	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	325		944	0	13	0	0	0	0	0	0	0	0	0	0	0	0
	326		166	0	0	.	0	0	0	0	0	0	0	0	0	0	0
	783	[1]	229	.	.	.	.	.	.	.	.	.	.	.	.	0	.
51-100	294	[4]	135	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	297	[4]	152	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	307		395	11	30	10	8	0	0	0	0	0	0	0	2	25	0
	311		317	0	71	13	547	4	36	2	0	1	0	2	0	3	3
	317		193	1425	1735	29	58	2	47	0	0	0	17	0	11	0	0
	319		984	74	154	55	175	156	78	981	.	9	0	0	0	0	35
	322		1567	21	51	0	11	0	2	0	0	0	0	0	0	0	2
	323		696	496	20	226	7	98	15	34	0	0	0	0	0	0	0
	324		494	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	781	[1]	446	.	.	.	.	.	.	.	.	.	.	.	.	0	0
	782	[1]	183	.	.	.	.	.	.	.	.	.	.	.	.	0	0
101-150	295	[4]	209	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	298	[4]	171	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	300	[4]	217	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	306		363	104	5	55	88	33	13	39	0	7	2	7	2	13	8
	309		296	67	43	104	56	3	8	22	16	20	3	8	41	22	29
	310		170	21	41	72	39	20	18	61	44	3	0	17	1	26	5
	313		165	126	31	46	46	15	77	107	200	13	77	20	165	451	178
	316		189	582	433	527	504	473	1234	452	730	10	847	.	656	115	35
	318		129	93	9	.	549	20	217	14	.	658	4	33	548	0	462
	779	[1]	422	.	.	.	.	.	.	.	.	.	.	.	.	0	0
	780	[1]	403	.	.	.	.	.	.	.	.	.	.	.	.	0	0
151-200	296	[4]	71	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	299	[4]	212	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	705		195	72	55	97	102	102	283	139	56	160	104	33	83	58	51
	706		476	404	304	217	451	563	371	165	345	704	471	280	518	284	406
	707		74	43	40	.	73	94	30	69	.	886	262	105	118	0	220
	715		128	63	22	.	55	50	42	111	16	0	16	5	42	28	43
	716		539	202	181	301	671	413	451	430	422	206	278	205	142	116	90
201-300	708		126	24	31	.	66	70	33	110	.	1050	73	102	26	116	24
	711		593	396	317	353	597	412	290	407	359	366	958	285	340	128	251
	712		731	272	.	512	548	256	355	247	207	447	769	294	133	216	430
	713		851	177	.	213	399	586	294	314	279	529	558	422	147	185	212
	714		1074	118	.	.	1068	392	683	484	484	738	627	238	205	107	300
301-400	709	[2]	147	1	1	.	.	.	.	47	.	125	.	36	21	7	236
401-500	710	[1]	156	5	4	3	8	.	2	.	.	7	.	7	0	10	.
501-600	776	[1]	159	.	.	.	.	.	.	.	.	.	.	.	.	.	.
601-700	777	[1]	183	.	.	.	.	.	.	.	.	.	.	.	.	.	.
701-800	778	[1]	166	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Total	[3]		4,955	3,738	2,835	6,223	3,863	4,594	4,256	3,159	5,937	5,065	2,098	3,207	1,913	3,029

[1] These strata were added to the stratification scheme in 1994.

[2] Strata 709 was redrawn in 1994 and includes the area covered by strata 710 in previous surveys. All sets done in 710 prior to 1994 have been recoded to 709.

[3] totals are for all strata fished.

[4] These strata were added to the stratification scheme in 1997.

Table 8. Mean bottom temperature data by depth zone, from sets in the Subdiv. 3Ps surveys.

		DEPTH RANGE (M)					
YEAR	SEASON	<55	56 - 92	93 - 183	184 - 275	>275	ALL DEPTHS
83	S	2.48	0.63	0.41	5.10	4.94	2.74
84	S	1.67	0.94	1.49	6.38	5.68	2.96
85	W	-1.15	-1.14	-0.14	6.09	6.18	2.37
86	W	-0.75	-0.95	0.46	7.35	5.90	2.39
87	W	-0.95	-0.72	0.14	5.84	5.17	1.80
88	W	0.15	0.29	0.73	5.95	4.94	2.51
89	W	-0.51	-0.37	0.03	4.20	5.15	1.91
90	W	-0.90	-0.82	-0.29	3.73	5.14	1.71
91	W	-0.28	-0.47	-0.14	4.06	4.99	1.91
92	W	-0.86	-0.69	0.03	5.24	4.95	2.00
93	W	-0.71	-0.75	-0.07	6.03	5.40	2.32
93	S	-0.40	-0.98	-0.81	6.22	5.68	2.32
94	S	0.53	-0.65	-0.58	3.65	5.24	1.85
95	S	0.29	-0.59	-0.11	3.87	5.32	1.96
96	S	1.11	0.35	0.87	4.22	5.30	2.46
97	S	0.16	-0.43	0.02	4.10	5.13	1.90
98	S	1.73	0.36	0.62	3.67	4.59	2.19
99	S	2.61	0.71	0.98	4.31	4.99	2.69
Mean		**0.23**	**-0.29**	**0.20**	**5.00**	**5.26**	**2.22**

Table 9. Stratified mean length (cm) at age for witch flounder from surveys in Subdivision 3Ps during 1983-94 using data converted to Campelen catch equivalents.

Male	Year												
Age (yrs)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 Feb.	1993 Apr.	1994
1	-	-	-	-	-	-	-	-	-	8.50	-	-	-
2	14.25	-	12.50	-	-	-	-	-	12.00	12.50	-	-	-
3	16.50	-	14.50	-	-	14.50	-	-	15.20	17.02	14.50	-	14.50
4	20.32	18.71	19.74	18.85	21.77		19.34		19.35	18.50	20.50	20.50	-
5	24.68	24.14	23.92	24.75	25.90	23.09	23.67	22.89	22.81	23.99	23.46	23.55	23.71
6	28.91	28.81	26.55	28.58	26.46	26.37	25.68	26.01	26.19	27.13	25.25	25.91	25.61
7	32.44	32.29	31.03	33.06	31.28	31.29	29.77	30.28	29.25	30.24	29.44	30.01	29.42
8	35.82	34.86	35.46	37.48	35.03	35.49	33.72	34.17	33.60	33.65	33.31	33.72	33.34
9	38.12	37.58	39.03	40.92	38.44	38.89	37.15	37.92	37.43	37.24	37.09	37.05	37.25
10	41.43	39.60	40.62	42.97	40.78	41.75	39.90	40.62	41.13	39.72	40.03	40.43	40.75
11	45.48	42.82	45.12	46.95	43.61	43.91	42.73	42.90	53.51	43.85	42.78	41.98	44.69
12	50.59	46.65	47.02	47.73	46.54	48.17	46.06	47.26	46.27	46.31	48.24	45.41	47.28
13	-	-	-	-	-	-	46.50	49.09	51.15	50.08	-	49.00	48.50
14	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-

Female	Year												
Age (yrs)	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 Feb.	1993 Apr.	1994
1	-	-	-	-	-	-	-	-	-	6.50	-	-	-
2	12.50	-	11.82	-	-	-	-	-	11.91	12.50	10.50	-	8.50
3	18.50	16.50	14.50	-	12.50	15.88	14.50	-	15.66	16.63	14.50	- -	
4	21.31	-	20.72	20.46	18.50	18.95	18.76	19.14	19.78	20.37	19.14	19.98	20.50
5	24.63	23.61	23.90	23.82	21.87	23.07	22.47	23.43	23.27	22.70	23.38	23.72	23.10
6	28.66	26.93	26.58	28.20	27.33	27.06	25.82	25.73	26.38	27.21	26.24	26.98	26.20
7	32.51	31.88	30.88	32.79	31.64	31.11	29.95	29.40	29.86	30.77	29.87	30.39	30.73
8	35.76	34.72	35.64	38.19	36.15	35.57	34.16	34.41	33.94	34.62	34.22	34.47	33.73
9	39.23	38.04	39.68	41.13	39.38	39.17	37.71	38.12	37.79	37.75	37.98	38.17	37.68
10	43.16	40.77	41.71	44.14	42.99	42.17	41.16	40.97	41.06	41.00	41.58	41.02	41.33
11	47.23	44.37	44.88	47.98	44.31	44.83	43.27	44.05	44.27	43.81	45.11	44.62	44.63
12	50.91	47.97	48.20	51.95	48.34	49.53	46.82	47.02	47.38	47.35	47.19	47.05	47.49
13	57.19	52.04	53.13	53.56	54.71	52.53	49.48	49.55	51.23	51.61	52.67	49.51	50.20
14	58.50	52.65	58.50	56.50	-	57.60	54.17	54.69	53.42	56.50	54.50	55.12	51.46
15	-	-	-	-	-	-	-	-	56.50	-	-	-	54.50

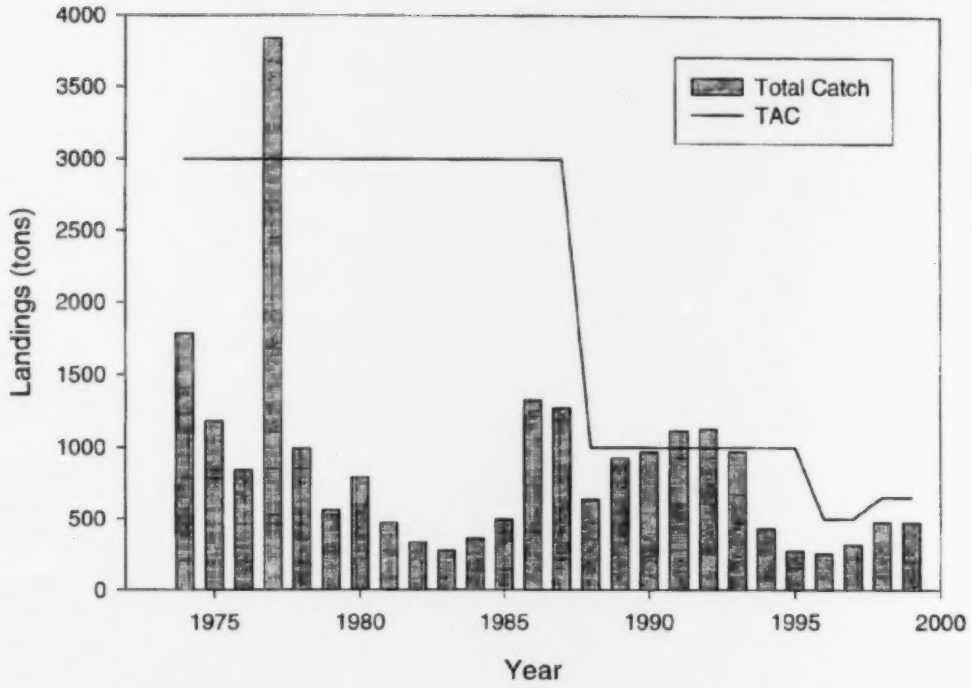

Fig. 1 Total landings and TACs of witch flounder from Subdivision 3Ps during 1974-99. The 1997-99 values are estimated from quota reports with 1999 representing the catch to the end of September.

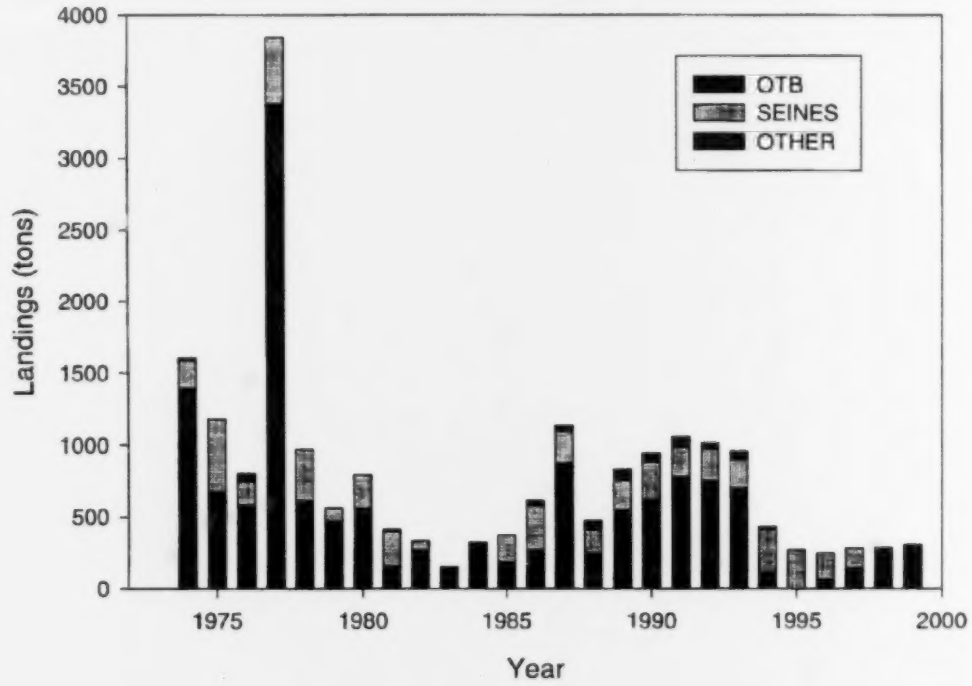

Fig. 2 Landings by gear type of witch flounder by Canada (N) from Subdivision 3Ps during 1974-99. The 1997-99 values are estimated from quota reports with 1999 representing the catch to the end of September.

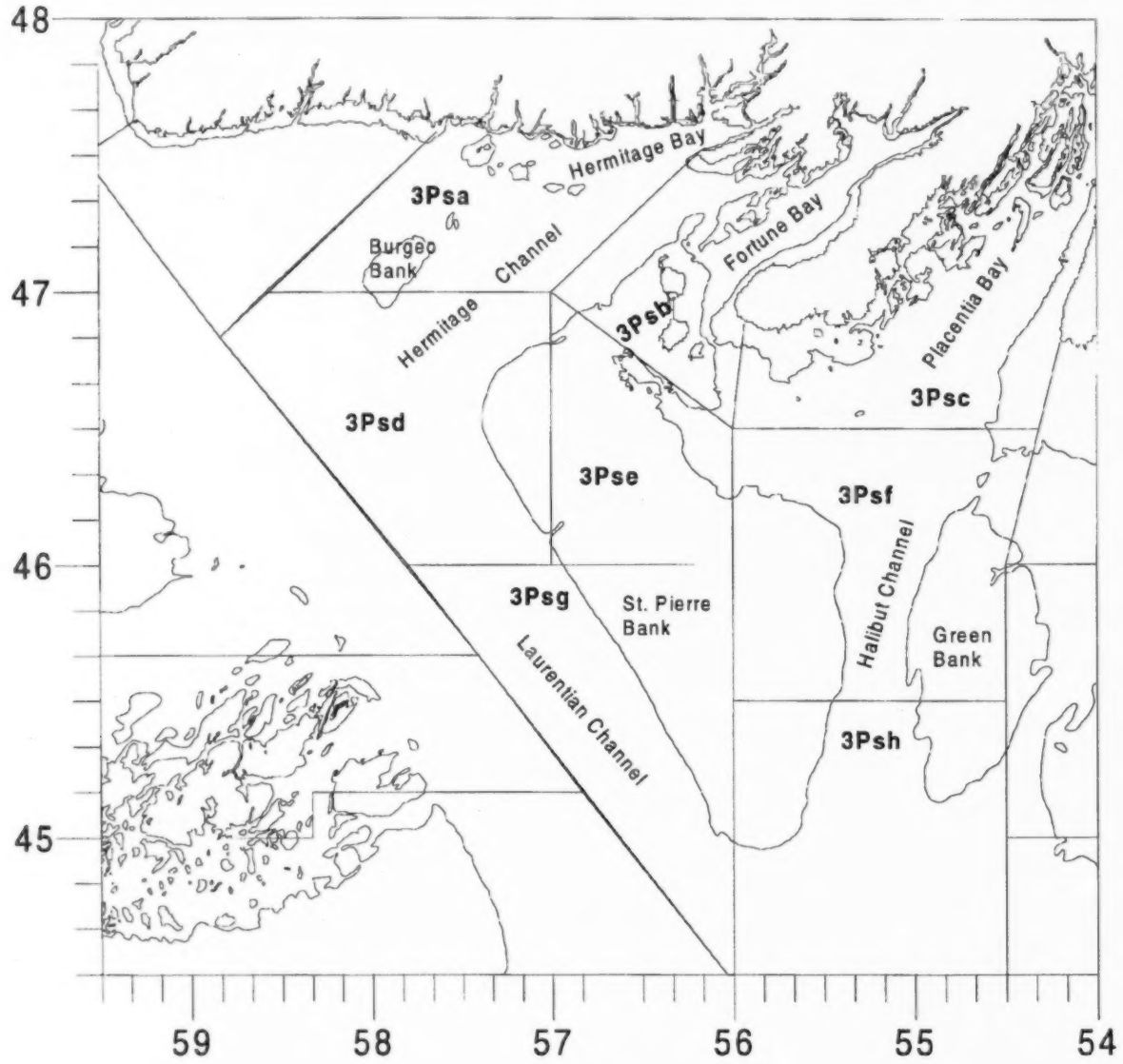

Fig. 3 Commercial catch reporting statistical areas for NAFO Subdivision 3Ps with the major place names mentioned in the text.

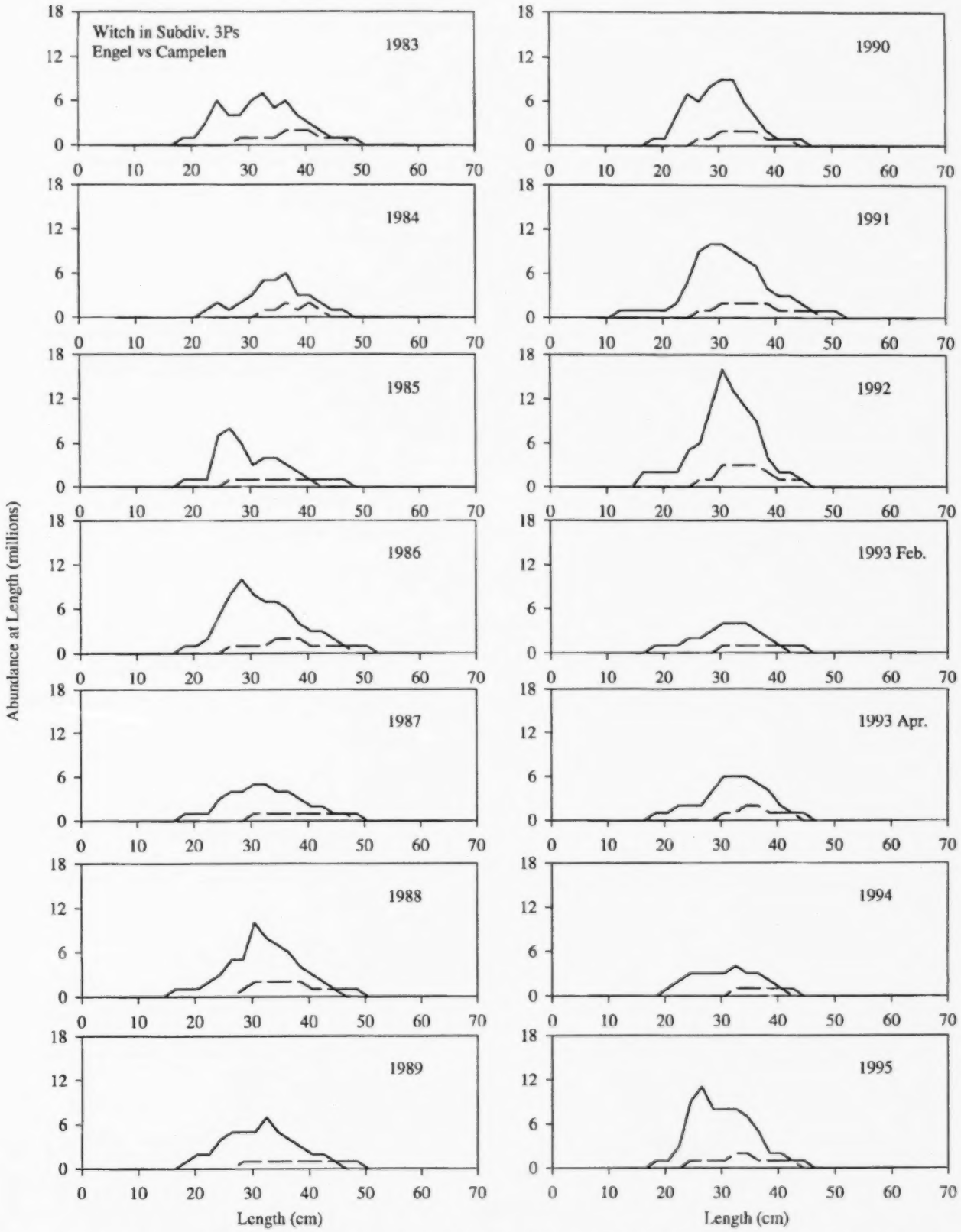

Fig. 4 A comparison of distribution and abundance at length (cm) between the Engel trawl and Campelen catch equivalents for witch flounder from Canadian surveys in Subdiv. 3Ps. Solid lines represent Campelen catches and broken lines represent Engel catches.

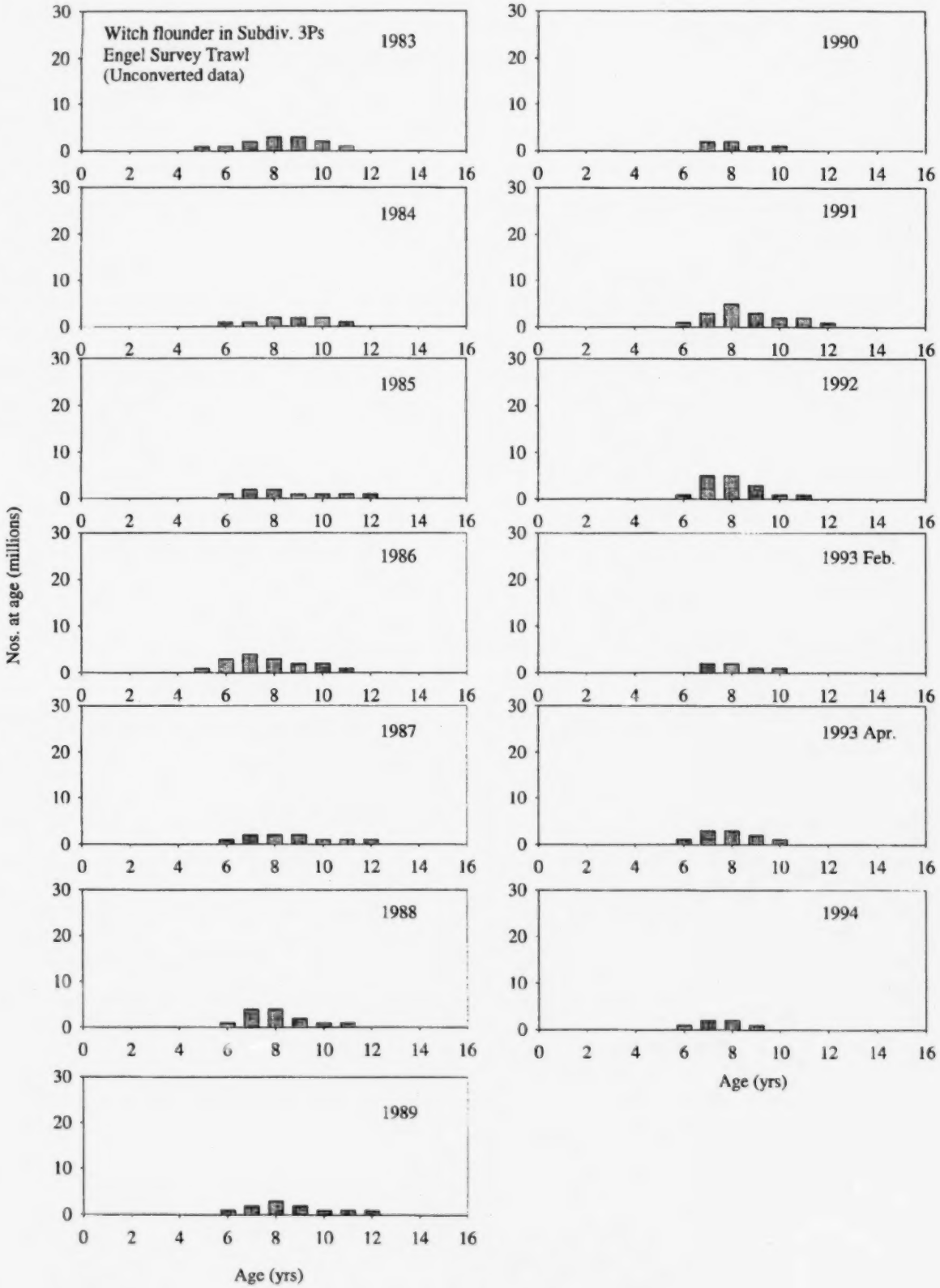

Fig. 5 Number at age (millions) of witch flounder in Subdiv. 3Ps from annual surveys during 1983-94. Surveys were conducted using an Engel otter trawl and are presented accordingly.

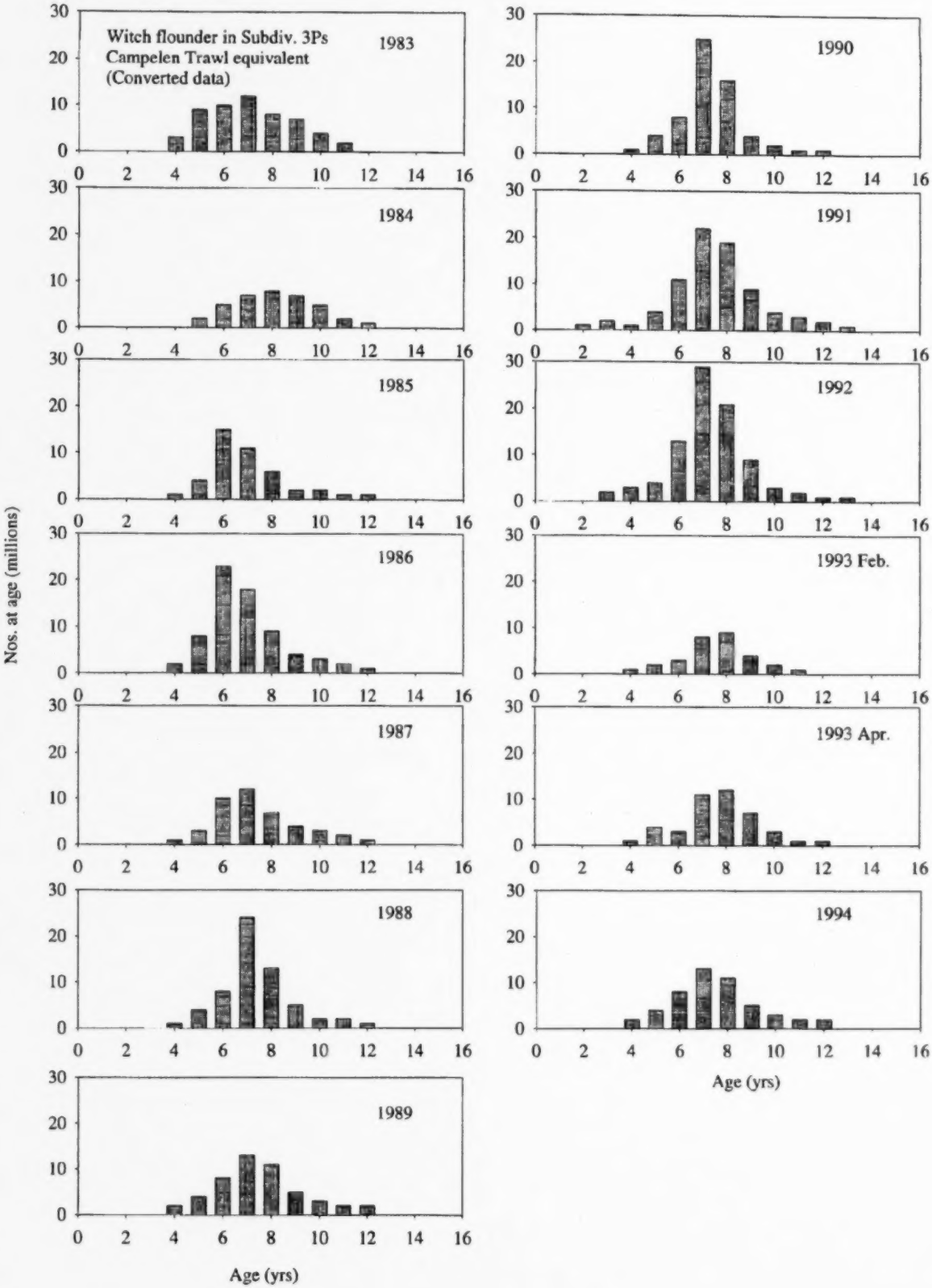

Fig. 6 Number at age (millions) of witch flounder in Subdiv. 3Ps from annual surveys during 1983-94. Surveys were conducted using an Engel otter trawl but data presented here have been converted to Campelen trawl catch equivalents.

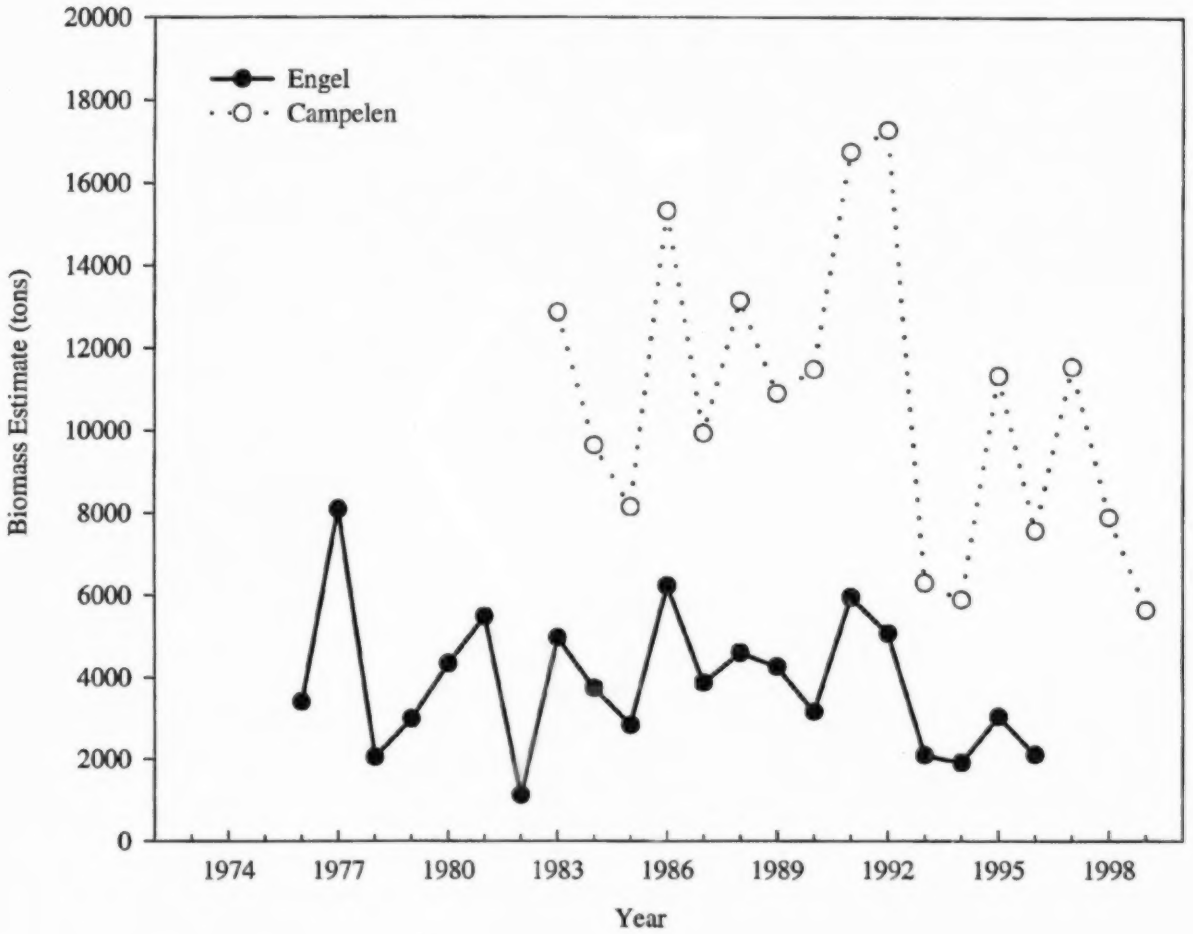

Fig. 7 A comparison between Campelen and Engel biomass estimates of witch flounder in Subdiv. 3Ps from Canadian surveys during 1976-99.

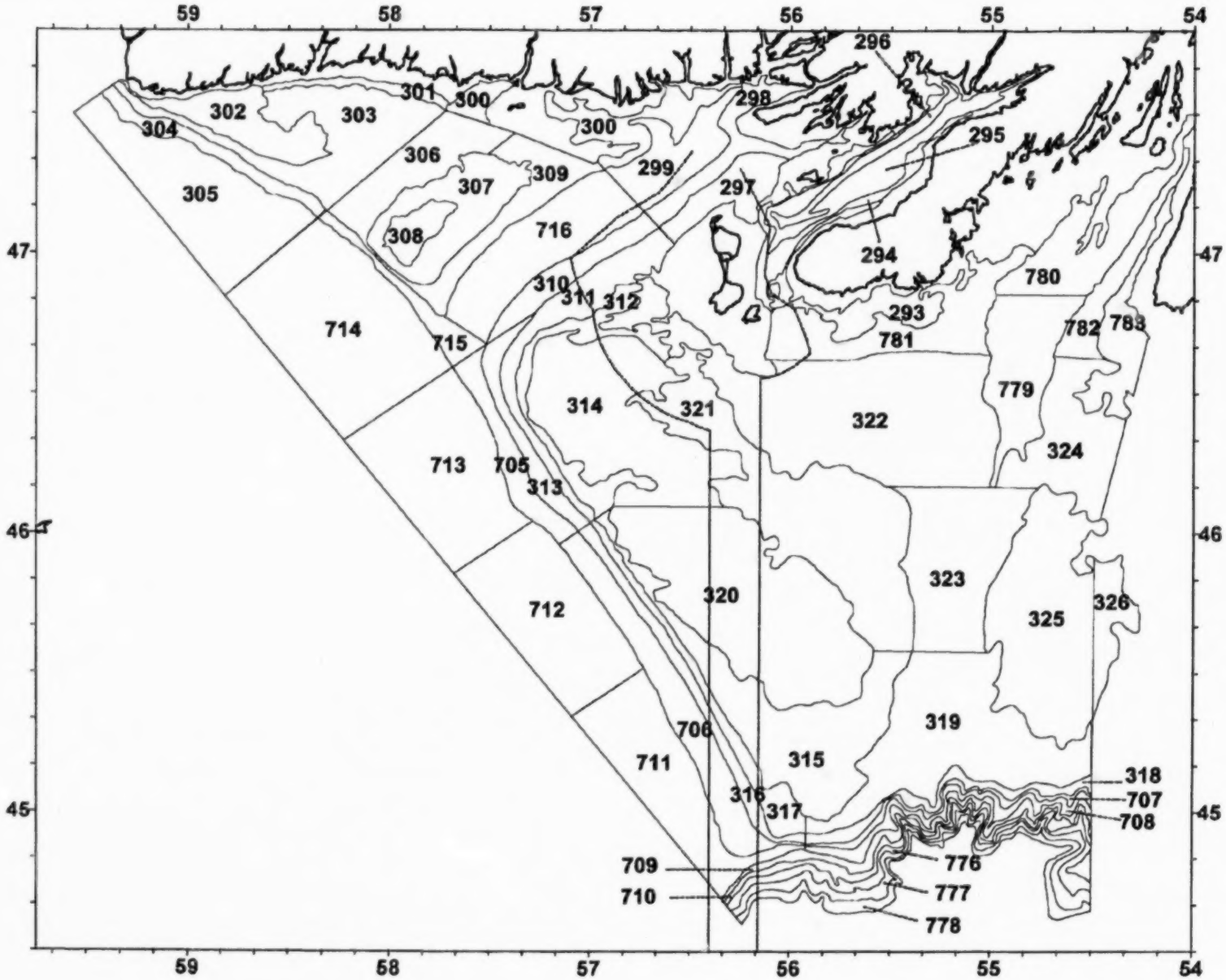

Fig.8 . The survey area in NAFO Div. 3P showing strata boundaries currently in use in the spring research vessel bottom trawl survey. (Revised Feb. 99)

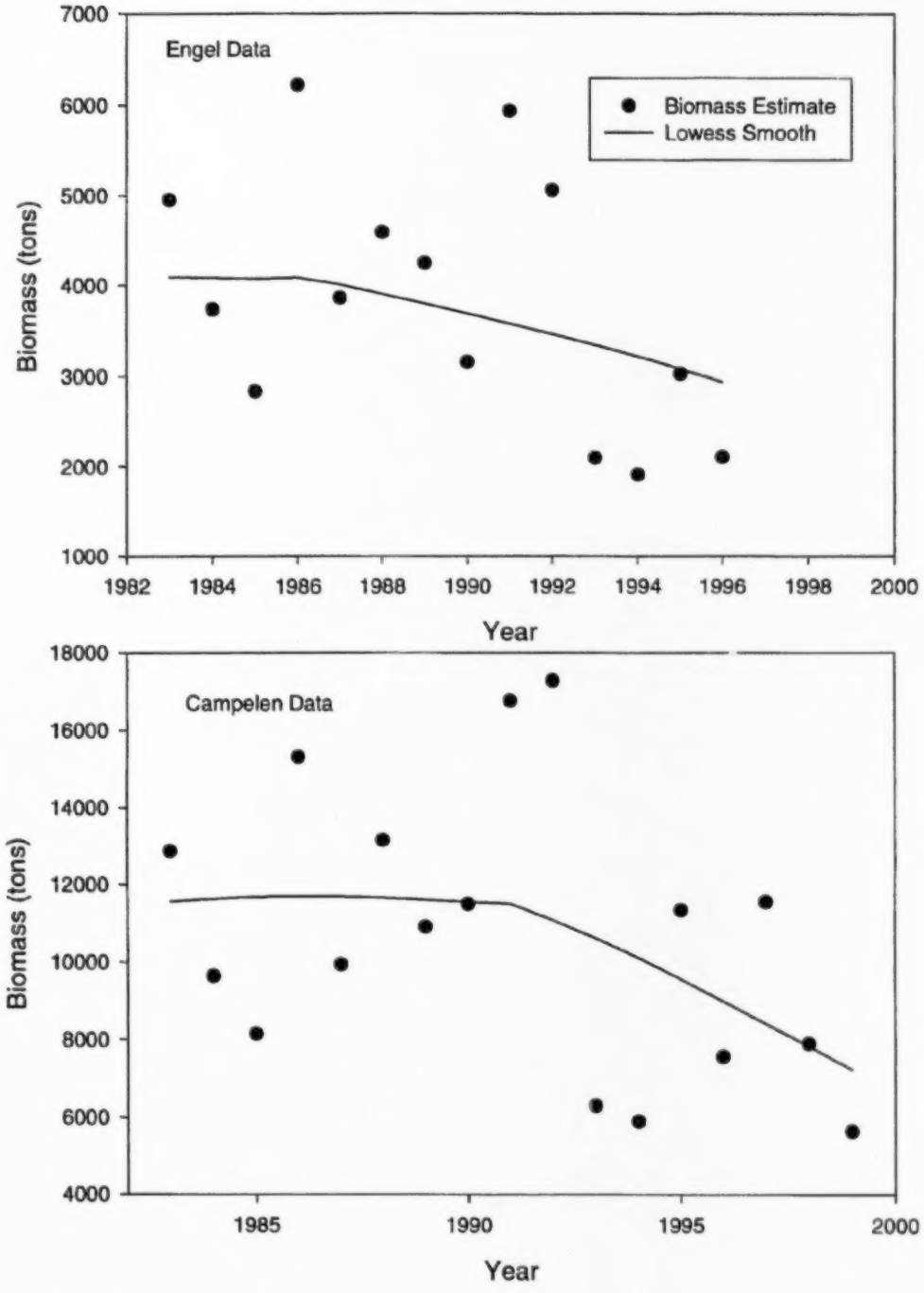

Fig. 9 Biomass estimates of witch flounder in Subdivision 3Ps from Canadian surveys in 1983-99. Upper panel is with unconverted data and lower panel is in Campelen trawl catch equivalents.

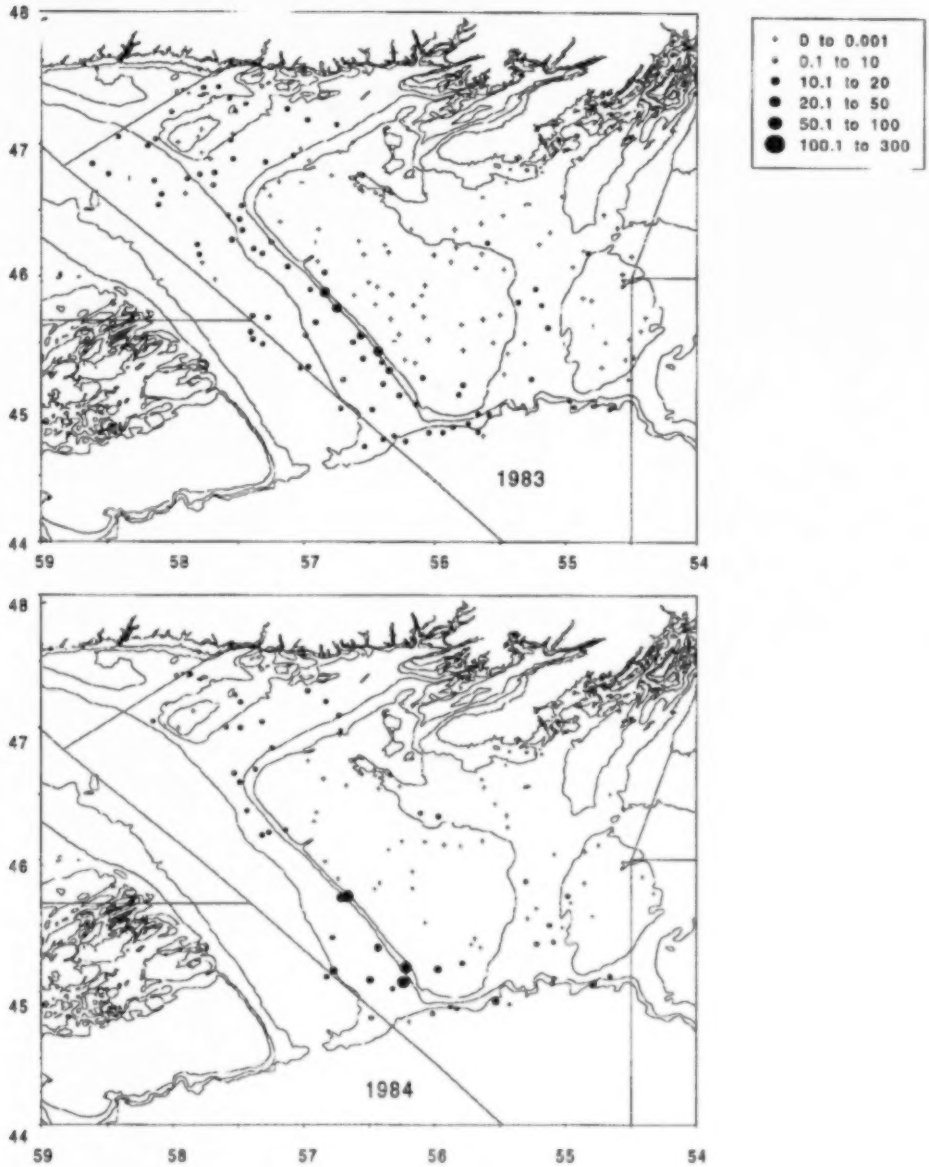

Fig. 10 Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

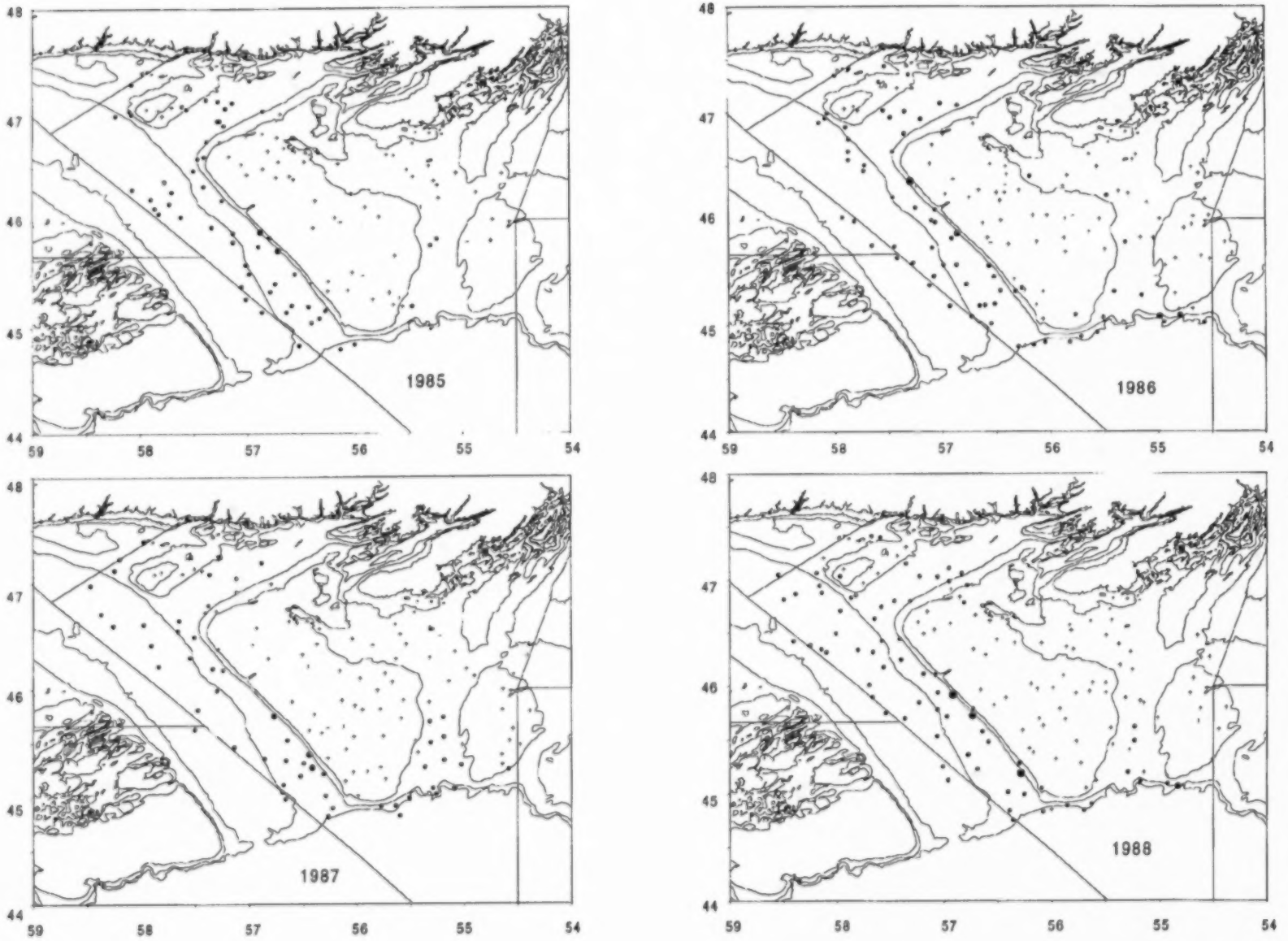

Fig. 10 (con'd) Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

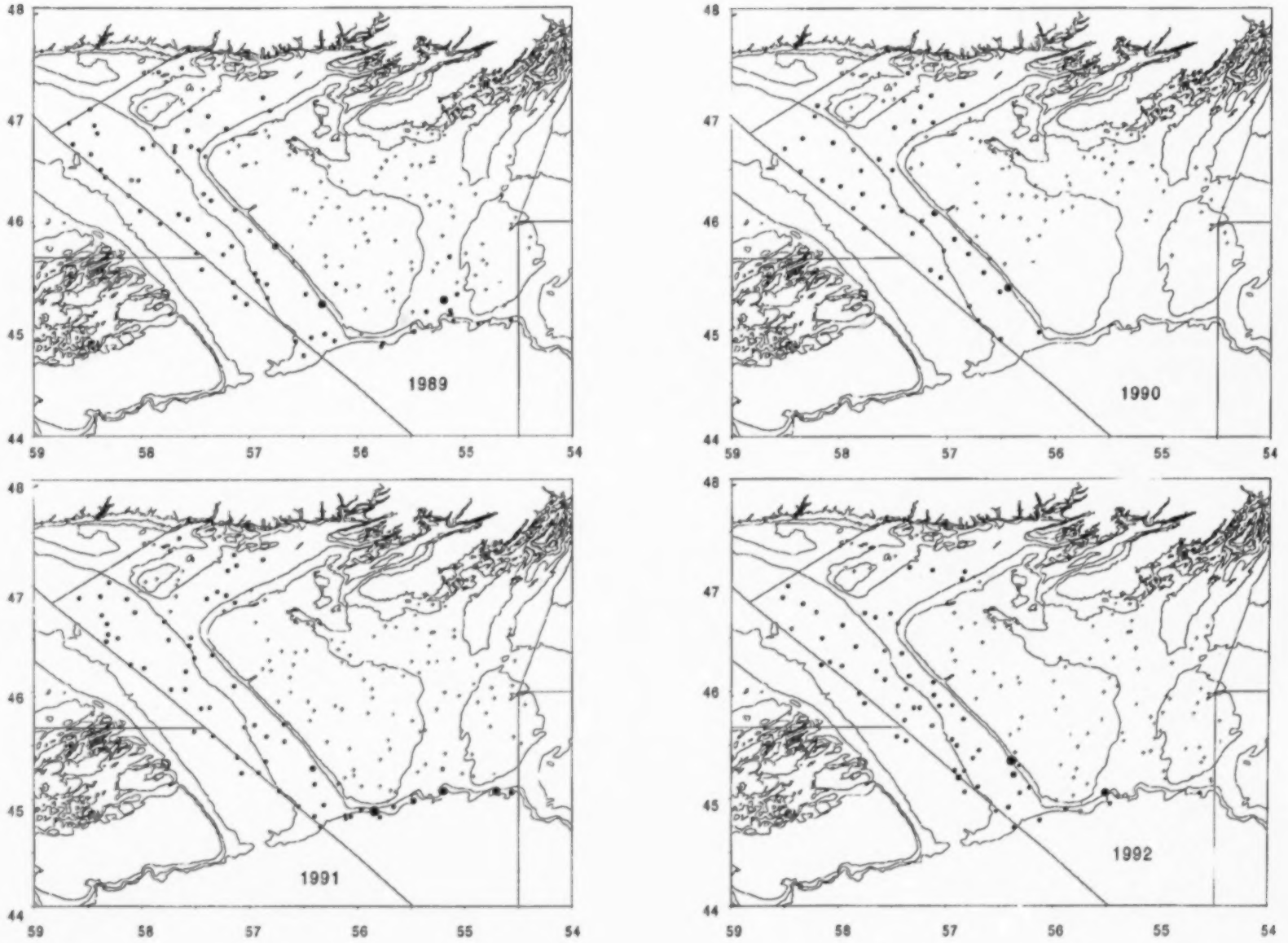

Fig. 10 (con'd) Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

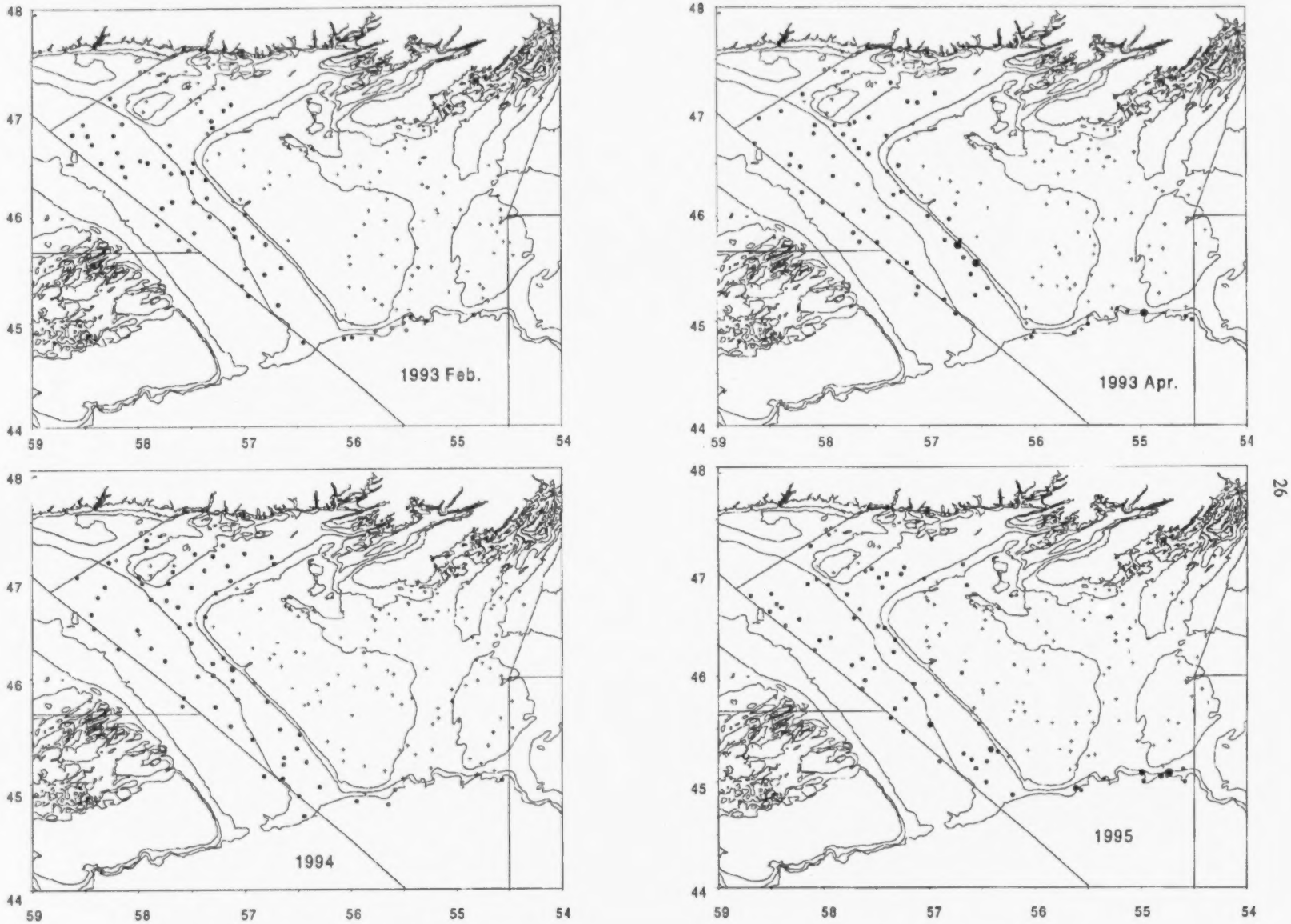

Fig. 10 (con'd) Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

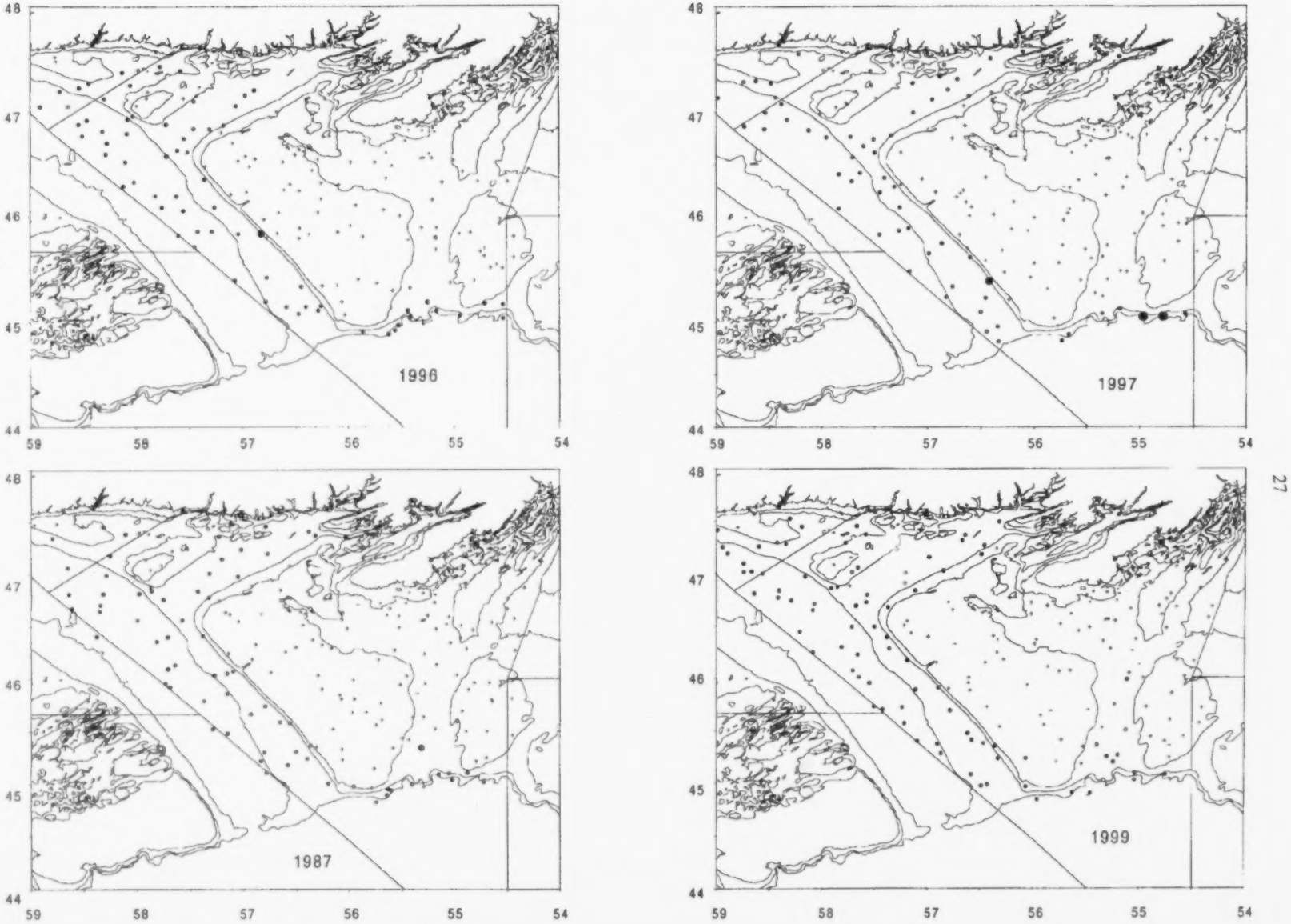

Fig. 10 (con'd) Distribution plots of witch flounder (kg/set) from Canadian surveys. Data are presented in Campelen trawl catch equivalents.

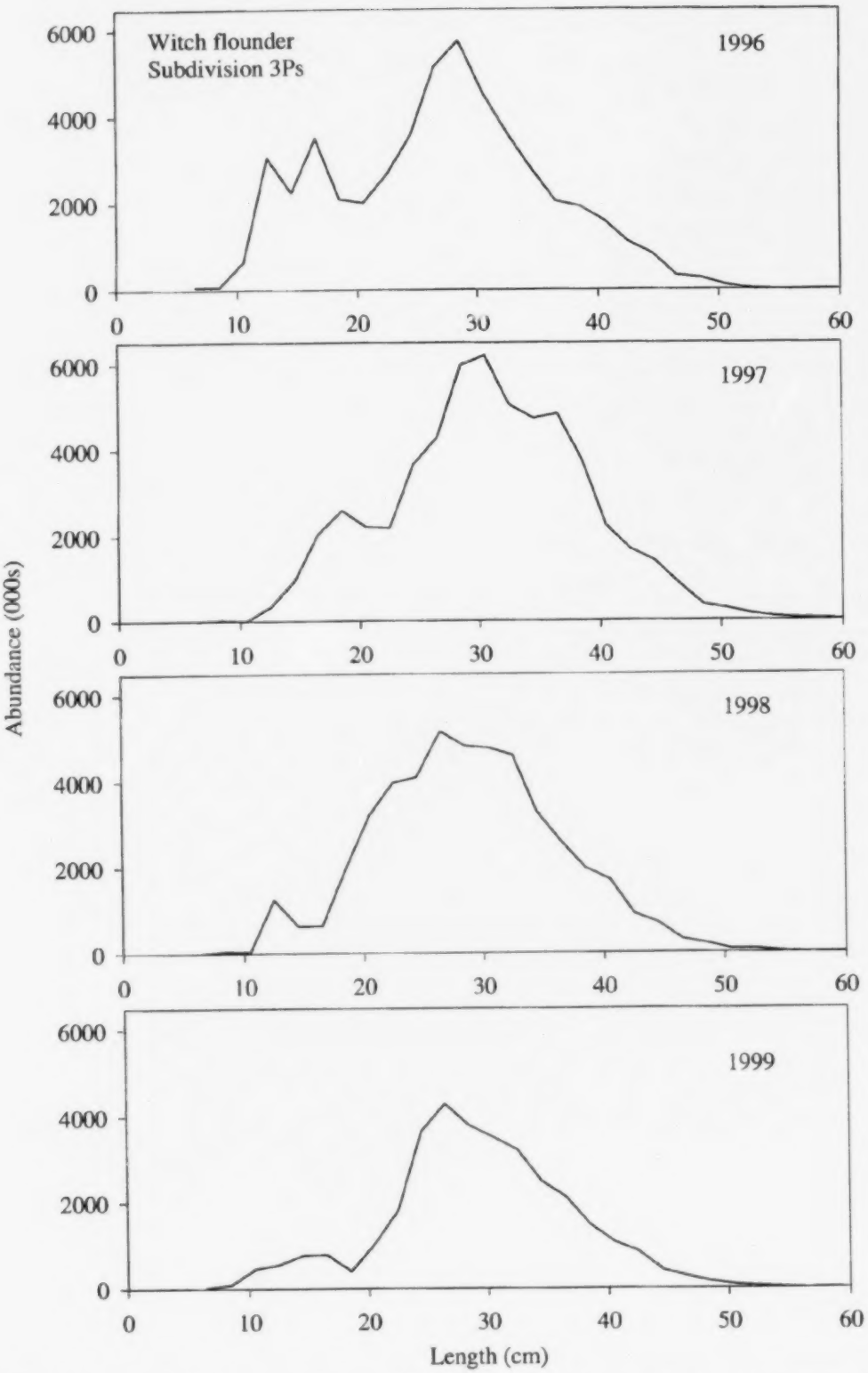

Fig. 11 Length frequency distributions of witch flounder from Subdivision 3Ps surveys in 1996-99 using the Campelen1800 shrimp survey trawl.

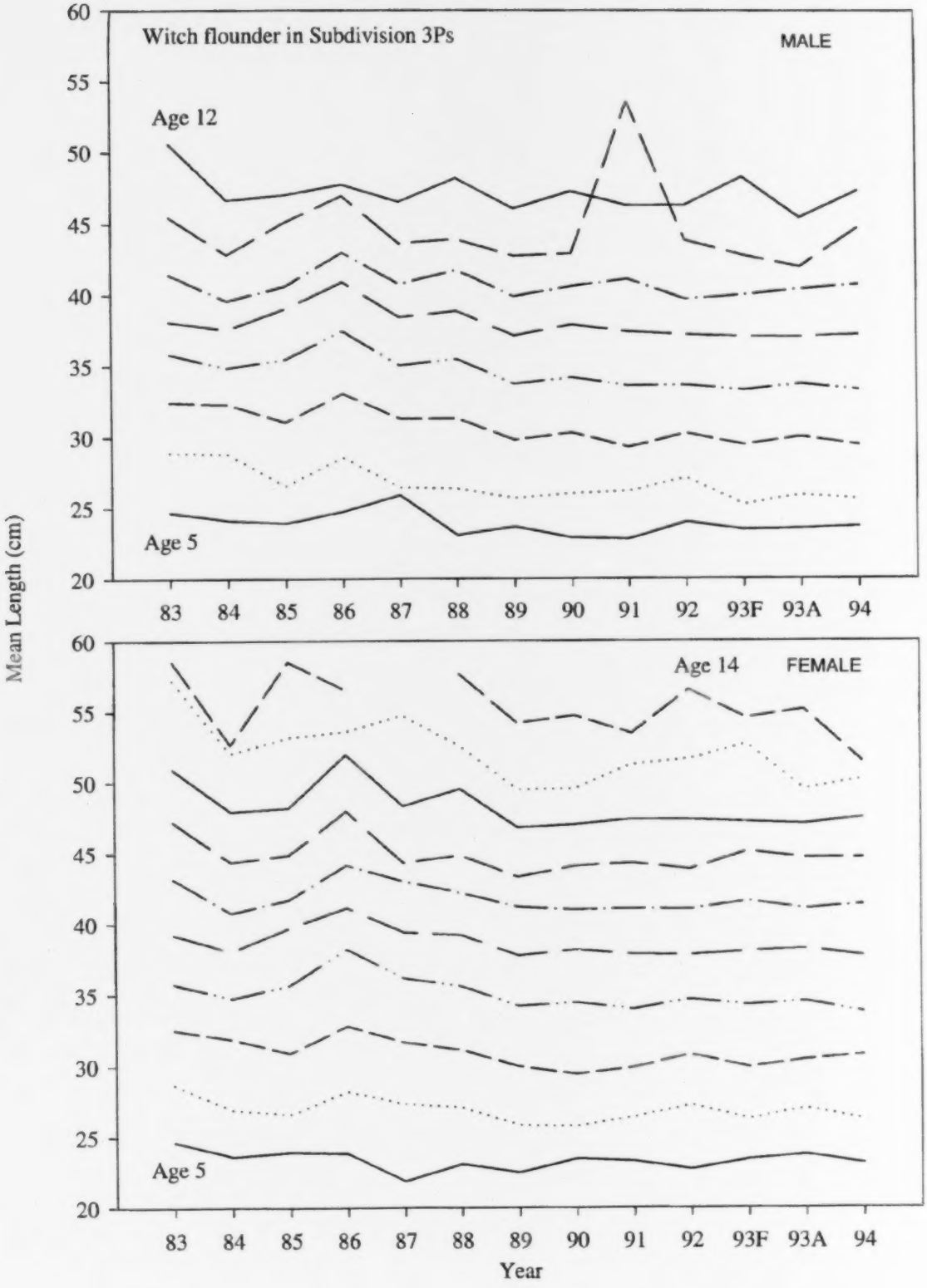

Fig. 12 Mean length (cm) at age for male and female witch flounder from surveys in Subdivision 3Ps during 1983-94. Data converted to Camelen trawl catch equivalents.

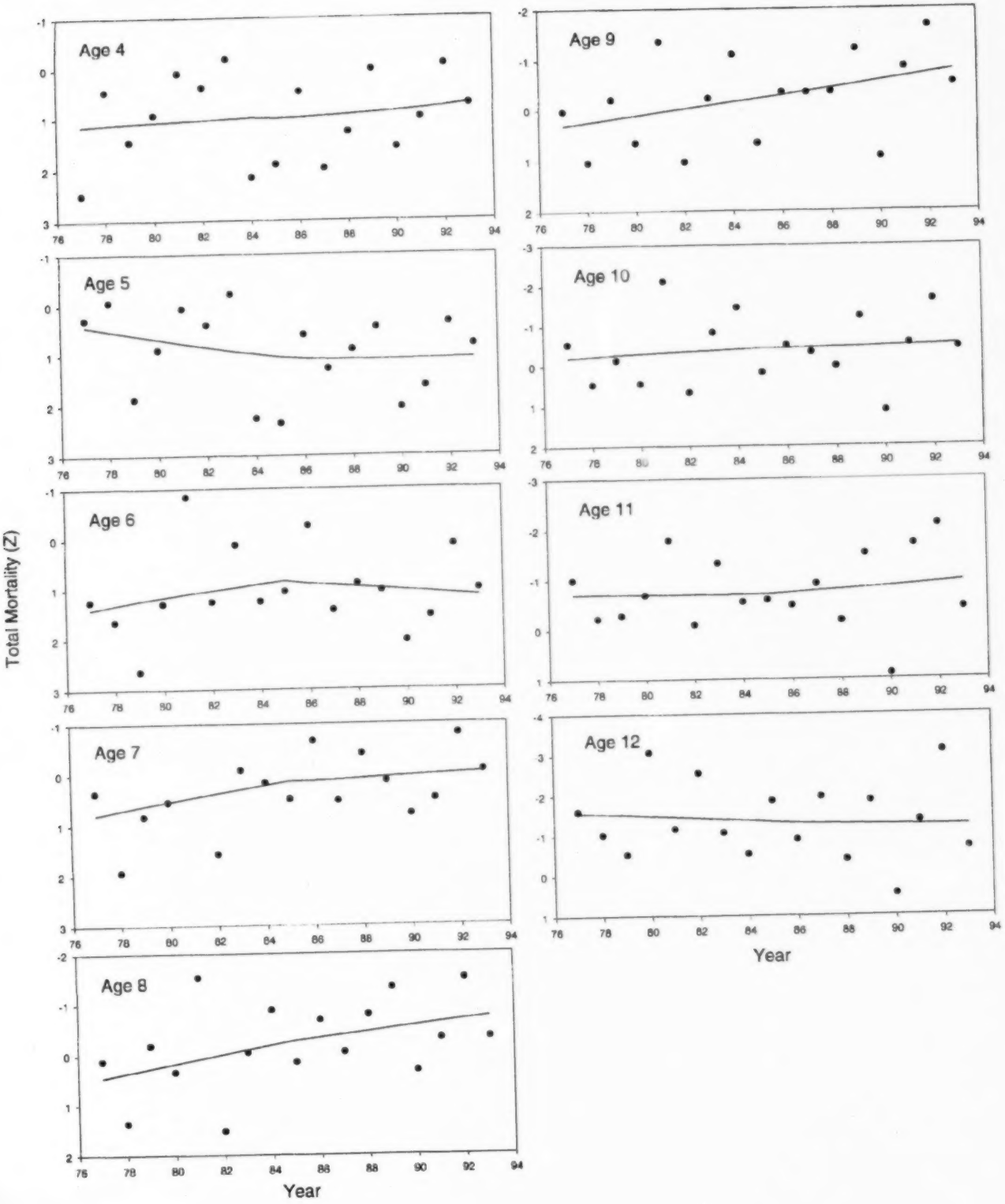

Fig. 13 Estimates of total mortality (Z) for ages 4-12 witch flounder from Canadian surveys in Subdivision 3Ps during 1976-94. Data are in Engel trawl catch equivalents.

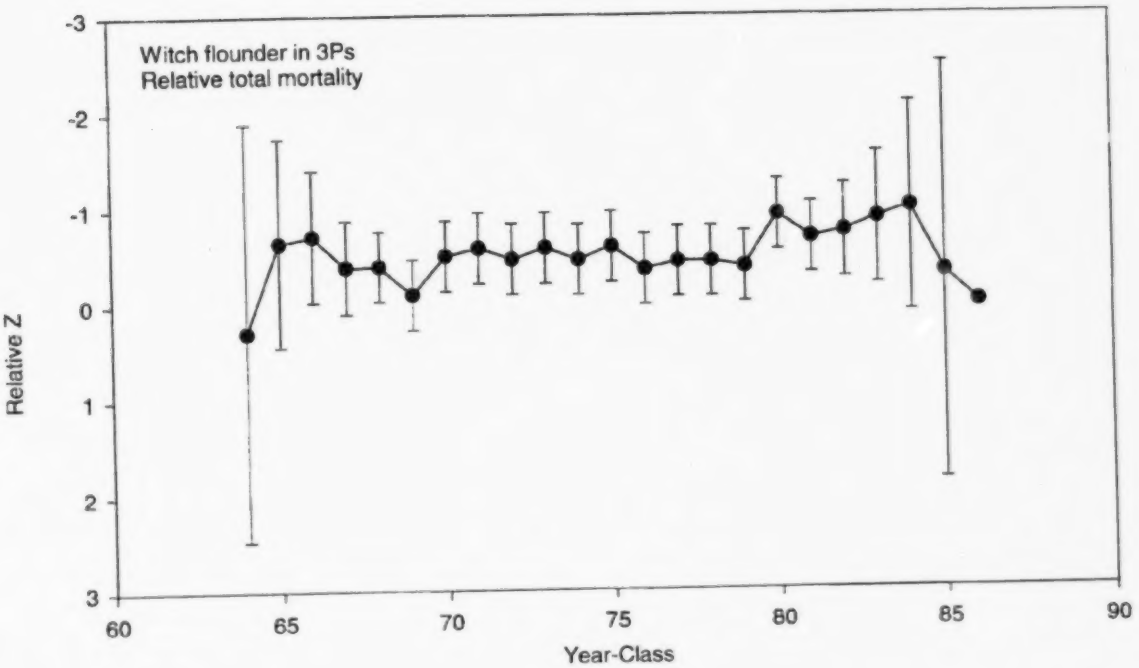

Fig. 14 Trend in relative total mortality of witch flounder fully recruited to the fishery (ages 8-13) in Subdivision 3Ps from the 1964-86 cohorts. Data from Engel surveys unconverted.